

BRIGHTNESS CONTRAST AND CHARACTER HEIGHT
OF FIVE FLAT PANEL COMPUTER DISPLAYS

by

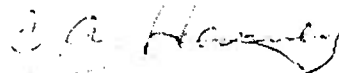
Kevin Laxar, Ph.D., David F. Neri, LT, MSC, USNR,
and Saul M. Luria, Ph.D.

NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

MEMO REPORT NUMBER 87- 5

Naval Medical Research and Development Command
Research Work Unit M0095.005-5010

Approved and Released by:



C. A. HARVEY, CAPT, MC, USN
Commanding Officer
NAVSUBMEDRSCHLAB

Approved for public release; distribution is unlimited.

SUMMARY PAGE

THE PROBLEM

To measure the character size and the brightness contrast of the flat panel display screens of five lap-top microcomputers under normal lighting and in the dark.

FINDINGS

The character height did not vary appreciably among the displays, but the contrast varied widely under different viewing conditions.

APPLICATION

These results are relevant to the choice of the most desirable computer display in particular viewing situations.

ADMINISTRATIVE INFORMATION

This investigation was conducted under Research Work Unit M0095.005-5010 -- "Sea trials for computer-based medical diagnostic/patient management system for use aboard SSN/SSBN submarines." The report was submitted for review on 19 August, approved for publication on 2 September, and designated as NSMRL Memo Rpt. 87-5.

PUBLISHED BY THE NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

BRIGHTNESS CONTRAST AND CHARACTER HEIGHT OF FIVE FLAT PANEL COMPUTER DISPLAYS

To help quantify the relative legibility of characters on the displays of five lap-top microcomputers, their brightness contrast and character height were measured. This was part of a comprehensive assessment of the suitability of these computers as an aid to medical diagnosis and record-keeping aboard submarines (Southerland, Moeller, Hamilton, & Perkins, in press). Since such computers would be used under different conditions, the measurements were made both in a normally lighted room and in the dark.

Method

The computers. Five lap-top microcomputers, each compatible with an IBM-PC, were evaluated (Table 1). The computers used widely different types of displays. The Datavue 25 and the Zenith Z-181 used a back-lighted liquid crystal display (LCD). The Toshiba T1100 Plus used an LCD that is not back-lighted. The other two used self-luminous displays. The Data General DG One, Model 2, had an electroluminescent (EL) display, and the Grid Gridcase 3 had a plasma display. All the computers displayed 25 lines of 80 characters.

Procedure. Each computer was set up in turn in a windowless room with normal overhead fluorescent illumination. The room illuminance was 2.7 lm/m^2 (lux) on a horizontal surface and 0.75 lm/m^2 on the vertical surface of the display screen, as measured with a Gossen Panlux light meter.

Tests were made with either fully charged battery packs or AC-converted power, and, when provided, controls were set for the optimal combination of brightness and maximum contrast.

Luminance measurements were made on the foreground and background areas of the display screen using a Photo Research PR-703A-PC Spot SpectraScan spectroradiometer. The measurements were made normal to the vertical screen surface, and at an angle of 45° in the horizontal plane. The screen of the Toshiba, which was not back-lighted, was tilted a few degrees off vertical to maximize contrast using the room illumination. While the screen angle of all the computers was adjustable, only the contrast of the Toshiba appeared sensitive to adjustment of the vertical angle. Measurements were also made with the room illumination off.

The height of upper and lower case characters was measured with a vernier caliper.

The contrast values were calculated using the following formula:

$$\text{Contrast (\%)} = \frac{|\text{Luminance Background} - \text{Luminance Foreground}|}{\text{Luminance of Lighter Area}} \times 100$$

where the foreground represents the displayed characters (Brown & Mueller, 1965).

Results

The luminance of the foreground and background of each computer display is given in Table 1 for each viewing angle under the light and dark conditions. Luminance measurements in the lighted room necessarily include components of the room illumination. No readings could be obtained for the Toshiba computer in the dark, since it had a reflective type of display screen.

The contrast of the display in the lighted room varied from 92% for the Data General to 23% for the Zenith, measured at the 45° angle. Although this is an appreciable difference, the displays of all computers were considered acceptably legible under most viewing angles.

Table 1
Luminance (cd/m^2) of the Foreground (FG) and Background (Bkgnd) Areas of the Flat Panel Computer Displays and their Contrast (%)^a

Manufacturer	Model	Display Type	Lighted Room			Dark Room		
			90°		45°	90°		
			FG lum.	Bkgnd lum. % Con.	FG lum. Bkgnd lum. % Con.	FG lum.	Bkgnd lum. % Con.	
Quadram	Datavue 25	LCD	28.5	75.1 62.1	33.3 55.5 40.0	26.3	71.5 63.3	
Data General	DG One Model 2	EL	11.4	0.87 92.4	7.2 0.65 91.1	10.0	0.17 98.3	
Grid	Gridcase 3	Plasma	8.4	2.0 76.6	8.2 1.3 83.6	6.5	0.02 99.7	
Toshiba	T1100 Plus	LCD ^b	9.3	40.8 77.1	4.8 11.8 59.2	-----	-----	
Zenith	Z-181	LCD	3.8	12.6 70.1	4.5 5.9 22.8	3.1	10.3 70.1	

a Minor discrepancies apparent in percent contrast are due to rounding of the given luminance values. b Not back-lighted.

Table 2
Screen Size, Character Height (in.), and Display Color of Flat Panel Computer Displays

Manufacturer	Model	Screen Size		Character Height		Color FG/Bkgnd.
		Height	Width	Upper Case	Lower Case	
Quadram	Datavue 25	4.00	8.87	0.144	0.109	Red/Yellow
Data General	DG One Model 2	4.87	7.75	0.170	0.130	Yellow/Black
Grid	Gridcase 3	3.87	8.75	0.137	0.098	Red-Orange/Black
Toshiba	T1100 Plus	4.00	9.00	0.137	0.093	Blue/White
Zenith	Z-181	6.09	8.09	0.207	0.148	Blue/White

The contrast threshold for perceptibility is around 2% (Blackwell, 1946), although it would not, of course, be comfortable to read anything at this level. But all these displays can be considered acceptable under normally lighted conditions.

In a dark room, of course, even dimly lighted characters are visible. However, the Toshiba had no self-lighted display and in the absence of ambient light, its display was invisible.

Table 2 gives the approximate screen size, the heights of the upper and lower case characters, and the colors of the display. The height of the upper case characters varied from 0.137 to 0.207 in.; that of the lower case characters varied from 0.093 to 0.148 in. Although this is, again, an appreciable range in mathematical terms, the differences were considered to not be of practical importance.

Comment

The screen size and character height of all the displays were judged to be adequate for normal viewing conditions.

The contrast of the displays also appeared to be adequate under normal office levels of illumination. In the dark, the contrast was, of course, even higher. The DG One and the Grid had very high contrast, but the Toshiba could not be seen at all.

The contrast values do not take into account any legibility effects due to the colors of the display. The colors of the text and background can affect legibility (Lippert & Snyder, 1986; Preston, Schwankl, & Tinker, 1932), but the combinations appeared to be satisfactory.

In summary, all the displays appear to be satisfactory under normal office conditions, but the Toshiba is unsatisfactory under low illumination.

REFERENCES

- Blackwell, H. R. (1946). Contrast thresholds of the human eye. Journal of the Optical Society of America, 36, 624-643.
- Brown, J. L., & Mueller, C. G. (1965). Brightness discrimination and brightness contrast. In C. H. Graham (Ed.), Vision and visual perception (pp. 208-250). New York: Wiley.
- Lippert, T. M., & Snyder, H. L. (1986). Unitary suprathreshold color-difference metrics of legibility for CRT raster imagery (Report No. HFL/ONR 86-3). Blacksburg, VA: Human Factors Laboratory, Virginia Polytechnic Institute and State University.
- Preston, K., H. P. Schwankl, & Tinker, M. A. (1932). The effect of variations in color of print and background on legibility. Journal of General Psychology, 6, 459-461.
- Southerland, D. G., Moeller, G., Hamilton, D., & Perkins, E. M. (1987). Laptop computer review (Memo Report No. 87-4). Groton, CT: Naval Submarine Medical Research Laboratory.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Memo Report No. 87-5	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) BRIGHTNESS CONTRAST AND CHARACTER HEIGHT OF FIVE FLAT PANEL COMPUTER DISPLAYS		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Kevin Laxar, David F. Neri, and Saul M. Luria		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Submarine Medical Research Laboratory Naval Submarine Base New London Groton, CT 06349-5900		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS M0095.005-5010
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research & Development Command NMCNCR Bethesda, MD 20814-5044		12. REPORT DATE 2 September 1987
		13. NUMBER OF PAGES 6
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) U
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Laptop computers; microcomputers; display systems; liquid crystal display systems; photometry; screens (display)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) To determine the relative legibility of the flat panel displays of five IBM-PC compatible lap-top microcomputers, their brightness contrasts and character heights, which generally contribute to legibility, were measured under normal lighting and in the dark. The Datavue 25, the Toshiba T1100 Plus, and the Zenith Z-181 used a liquid crystal display in various foreground/background color combinations. The Data General DG One had an electroluminescent display, and the Grid		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Gridcase 3 used a plasma display, both of which are self-luminous.

The brightness contrast of all the displays was acceptable under normal lighted conditions. The DG One had the highest contrast in a lighted room (92%), at viewing angles both normal to the vertical screen surface and at 45° in the horizontal plane. The DG One and the Gridcase 3 had the highest contrast in the dark (over 98%). The Toshiba's screen was not backlighted and could not be used in a dark room.

All the screens displayed 25 lines of 80 characters. The height of upper case characters ranged from 0.137 to 0.208 in., and all were acceptable for normal viewing distances.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)